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PATENT SPECIFICATION

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(54) METHOD AND APPARATUS FOR DISCHARGING INERT GAS FROM FUEL-CELL BATTERIES

(71) We, VARTA AKTIENGESELLSCHAFT, a German Company of Patentabteilung, Frankfurt am Main, Neue Mainzer Strasse 54, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a method and apparatus for discharging the inert gas from fuel-cell batteries, in which the gas mixture flows in series through some of the gas spaces of the electrodes of one polarity.

In United Kingdom Patent Specification No. 949,802 there is described and claimed a method of operating a fuel-cell battery in which the reaction gas contains an inert gas and in which the gas flows successively through the electrode spaces, the cushions of inert gas collected in the gas space of the last electrode being controlled by measuring the polarisation of that electrode and being continuously discharged when a threshold value is reached.

There thus arose the problem of finding a method in which as little as possible reaction gas would be lost when the inert gas mixture is discontinuously blown-off from the gas space of the last electrode.

When the inert gas has been blown off, the reduction in the output of the last electrode resulting from the inert gas cushion is balanced with a certain amount of delay and for a period after the blowing-off process, the output of the elctrode or of its associated fuel cell is thus still close to the threshold value at which the blowing-off process is initiated. It has thus been necessary to find a method, by which the initiation of a subsequent blowing-off process is blocked for a determined period of time after the first blowing-off process.

These problems are solved by the present method of discharging inert gas from fuel-cell batteries. The gas mixture flows in series through at least some of the gas spaces of the electrodes of one polarity. The blowing-off of the mixture of inert gas and residual reaction is controlled by the output of the last electrode. The method is characterised in that when the output of the last electrode drops to a determined value, a blow-off valve is opened for a determined period of time followed by a blocking of the operation of the value for an adjustable dead time.

In carrying out the method according to the invention, it is particularly advantageous to use a regulating circuit consisting of a two-stage transistor direct current amplifier. A solenoid valve is operated by a relay provided in the output circuit of the second amplifier stage. The period for which the valve is opened is determined by a capacitor parallel to the coil of the relay. The second amplifier stage is preceded by an additional control transistor. The base-voltage divider of the additional control transistor contains a capacitor which is discharged when the relay is in the operative position. The charging period of the capacitor corresponding to the dead time commences when the relay is de-energised.

One embodiment of the invention is hereinafter described and illustrated in the accompanying drawing which is a circuit diagram of the invention.

A housing 1 contains a hydrogen-oxygen fuel-cell battery comprising 16 cells. The individual gas spaces of the oxygen electrodes are connected in series. The fuel cell of which the oxygen electrode is the last electrode to be reached by the gas mixture, supplies the signal voltage for the base of a transistor T1 of the first stage of the direct current amplifier. A suitable voltage may be applied to the emitter of transistor T1 by the voltage-divider circuit of resistors 2, 3, 4 and of a potentiometer 5. The amplifier stage with transistor T1 may thus be so adjusted that the inert gas is blown off when the last fuel cell in the battery has a given voltage. The collector of the transistor T1 is connected by a Zener diode 6 to the base of a transistor T2 of the second direct-current amplifier stage. The transistor T2 through which normally no current flows, is opened upon suitable adjustment of the direct-current amplifier with transistor T1. The relay 7 is then operated by the collector

current of transistor T2 and the two switch contacts 8 and 9 are closed. Switch contact 8 causes a solenoid valve 10 to be supplied with the full voltage of the fuel-cell battery or any other suitable switching voltage and thus to be opened. The solenoid valve 10 remains in the open position until the capacitor 11 has been discharged through the resistor of the coil of relay 7. The transistor T2 is then again blocked and is not opened until the voltage of the last cell in the fuel-cell battery is below a determined threshold value.

The solenoid valve 10 has to be prevented from being re-opened during an adjustable dead time. When the solenoid valve 10 is opened, a sufficient amount of inert gas is blown out from the gas space of the last oxygen electrode in the fuel cell battery within a fraction of a second of the period for which the valve is open. However, when the inert gas has been blown off, a certain period of time has to elapse until the voltage in the last fuel cell rises again to a value above the threshold value. If no means for adjusting the dead time were provided, the solenoid valve would, in that event, be re-opened and excessive reaction gas would be lost during the blow-off period. The dead time may be adjusted by an auxiliary circuit comprising a transistor T3, a resistor 12, two resistors 13 and 14, a capacitor 15 and a switch contact 9. The switch contact 9, which is operated together with the switch contact 8 by the relay 7, is open whenever the solenoid valve 10 is closed or the relay 7 is not operated. During the period for which the relay 7 is open, the switch 9 is closed and the capacitor 15 is discharged through a relatively small resistance 14. Upon termination of the period during which the relay 7 is open, the switch 9 is opened and the capacitor 15 is charged through resistors 12 and 13. The resistors 12 and 13 form a voltage divider for the base of transistor T3.

During the charging period of capacitor 15, a suitable bias is thus applied to the base of transistor T3, so that the transistor carries current. The transistor T2 is then blocked, since the base and the emitter of transistor T2 are interconnected by the current-carrying transistor T3.

The resistance 16 is the working resistance of the transistor T1. If T1 is conductive, then the collector current causes a drop in voltage across the resistance 16, so that a relatively positive potential prevails at position P1: T2 remaining non-conductive. As soon as T1 becomes non-conductive, for example due to a drop in potential in the control cell, the potential at position P1 becomes negative and T2 becomes conductive. The resisitor 17 and the zener diode 18 produce a stabilising connection which enables a stable voltage to be obtained at position P2. This stabilisation has proved to be very advantageous to protect the regulator against disturbances from the charge of the battery.

WHAT WE CLAIM IS:—

1. A method of discharging inert gas from fuel-cell batteries, in which the gas mixture flows in series through at least some of the gas spaces of the electrodes of one polarity and in which the blowing-off of the mixture of inert gas and residual reaction gas is controlled by the electric output of the last electrode, in which when the output of the last electrode drops to a determined value, a blow-off valve is opened for a predetermined period of time, the operation of the valve being then blocked for an adjustable dead time.

2. In the method according to Claim 1, the use of a regulating circuit consisting of a two-stage transistor-direct current amplifier, in which a solenoid valve is operated by a relay provided in the output circuit of the second amplifier stage, the period during which the valve is open being determined by a capacitor parallel to the coil of the relay, the second amplifer stage being preceded by an additional transistor, the base-voltage divider of which additional transistor contains a capacitor discharged when the relay is in its operative position, the charging period of the capacitor corresponding to the dead time.

3. A method of discharging inert gas from fuel-cell batteries, substantially as hereinbefore described and as illustrated in the accompanying drawing.

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1 SHEET This drawing is a reproduction of the Original on a reduced scale